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Original Article

The effects of oral health education on long-term variations in periodontal status of diabetics

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Purpose: The aim of this study was to evaluate the long-term effects of oral health education program on periodontal status of patients with diabetes mellitus (DM).
Materials and methods: A one-year longitudinal cohort method was implemented and long-term evaluations of periodontal status of DM patients were conducted in a medical center in Taiwan from Jan 2008 to Dec 2008. Variations in oral health behaviors and habits were used to assess the long-term effects of oral health education on periodontal status by Community Periodontal Index (CPI).
Results: In total, 95 qualified DM patients were enrolled in this study. Among them, 70.5% presented with periodontitis in the initial epoch compared with only 20.0% in the final epoch. Significant changes in periodontal status ($p<0.01$) revealed the long-term effects of implementation of oral health behaviors and habits gleaned from oral health educational courses. Major determinants of the long-term variations in periodontal status were changes in cigarette smoking and dental floss use on generalized estimating equation (GEE) modeling.
Conclusions: Our results revealed that oral health education can reduce incidence of periodontitis in DM patients. Further large-scale research is needed to confirm our findings.

Keywords: longitudinal cohort study, oral health education, diabetes mellitus, periodontitis, Community Periodontal Index (CPI)

Introduction

Periodontitis is a general chronic inflammatory disease that presents with pathological changes in the periodontal ligament and alveolar bone of the teeth[1-2]. Clinical evidence has revealed a significant correlation between periodontitis and diabetes mellitus (DM) and many epidemiological surveys have confirmed that DM is one of the major risk factors for periodontitis[3-10].

A study was conducted on the epidemiology and risk factors/indicators of gingivitis, aggressive periodontitis (AgP) and chronic periodontitis (CP) in a Jordanian population. The results indicated that low education levels (attitude toward oral health) and low frequency of tooth brushing are significantly associated with increased risk of periodontitis. The authors recommended larger-

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scale whole country studies to investigate the prevalence of periodontitis and longitudinal studies to elucidate whether the risk indicators are true risk factors[11,12]. Another cross-sectional study was conducted among adolescents 15-18 years of age in Mangalore City. The authors assessed the prevalences of AgP and CP using community periodontal index (CPI) and indicated high prevalences of gingivitis and periodontitis associated with lower socioeconomic status. In turn, lower socioeconomic status was associated with poor oral hygiene habits due to poor oral health education and dental care utilization[13]. Two additional cross-sectional studies assessed oral health behaviors and attitudes, as well as their relationships with periodontal status (CPI score), among students in India. The authors concluded that to achieve better oral health, there is a need for oral health promotion, including oral health education and care, as well as a positive attitude and adherence to good oral hygiene behaviors[14,15].

There is emerging evidence to support the existence of a two-way relationship between DM and periodontitis. DM and its complications increase the risk of periodontitis and periodontal inflammation affects glycaemic control in DM patients. Incidences of macroalbuminuria and end-stage renal disease are higher among individuals with DM and severe periodontitis. Several clinical and animal studies have indicated that DM in T2DM patients and DM animals is a significant factor in inflammation syndrome, independent of the periodontal status[16,17]. Although the causal relationship is still unclear in the real bidirectional influences of DM patient glycemic levels and periodontal problems[18-21], previous studies have shown positive impact of Health Coaching (HC), compared to Health Education (HE), on CPI scores and DM management among DM patients[22-25].

The association between DM and periodontal diseases is well-established. Therefore, periodontal health intervention should be an integral component of DM management[26-31]. The aims of this study were to use generalized estimating equation (GEE) modeling to understand the long-term effects of changes in oral health behaviors and habits on the improvement of periodontal health and to evaluate the long-term effects of oral health education on periodontal status among patients with DM.

Materials and methods

Adult DM outpatients were enrolled in this longitudinal cohort study from Jan 2008 to Dec 2008. Based on the PRECEDE-PROCEED Model[32], we provided a series of oral health educational courses (one time per participant) to help these patients correct their oral health problems in the initial period of this study. The courses included introductions to DM and oral health, VCR review, and oral health examinations by experienced physicians and DM nurses. Four follow-up oral health surveys were carried out in the 3rd, 6th, 9th, and 12th months, respectively, in tracking clinic and by telephone to identify the effects of health education outcomes on these patients' periodontal status. Exclusion criteria were age nineteen years and below, refusal to participate in this study, and less than two visible index teeth in one of six sections of CPI. At the baseline visit, all participants provided informed consent, although ethical approval was not a mandatory provision in 2008. The detailed procedures are outlined in Figure 1.

Periodontal examination is a clinical examination of the periodontium and routinely carried out in dentistry and allied specialties. Many different techniques are used around the world with CPI recommended by the World Health Organization (WHO). In brief, total teeth of clients were divided into six sections that included ten index teeth and evaluated by an experienced dentist. The intervals of CPI were recorded as total scores for each segment ranging from zero to four points with cut-off defined as three points. A score of three points and above was classified as periodontitis. CPI rankings were as follows: (a) code "0" no disease (no gingival pockets >3 mm) and no action required; (b) code "1" bleeding on probing (no gingival pockets >3 mm) with need for oral hygiene instruction as bleeding on probing indicates the presence of plaque-induced gingivitis; (c) code "2" no periodontal pocketing >3 mm, the calculus presents with or without plaque retentive

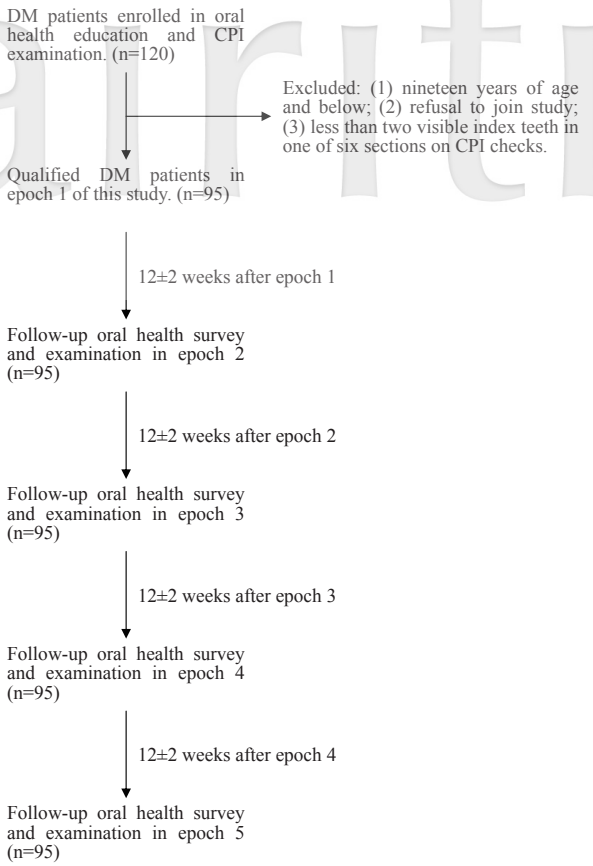

Fig. 1. Sampling and follow-up procedures in this longitudinal cohort study.

factors such as overhanging restorations with need for oral hygiene instruction to remove plaque retentive factors; (d) code "3" shallow periodontal pockets 4-5 mm (i.e. first band on probe partially visible); (e) code "4" deep periodontal pockets >6 mm (first band on probe disappears). When CPI code was "3" or "4", further detailed (not forced) periodontal examinations and treatments were suggested.

The dependent variables in this study included (a) utilization habits of toothbrush, dental floss, mouthwash, cigarettes, and areca; (b) brushing habits categorized into three frequency levels: once a day, twice a day, and three times or more a day; (c) frequency of use of dental floss, mouthwash, cigarettes, and areca categorized as never, former user, and current user; (d) demographic data such as gender, age (years), educational level (years), and disease duration (years). Data on treatments after our health education intervention were unavailable. Thus, the interaction between treatment and changes in CPI score was not analyzed in this study.

In addition to the demographic data, other determinants were measured five times during the different epochs in this study. The longitudinal data were analyzed on GEE multivariate analysis by SPSS 17.0 software, followed by evaluation of the longitudinal, long-term trends in CPIs. The dependent binary variable of the outcome was CPI score (reference=periodontitis). In addition, the change in periodontal status between initial and final epochs was analyzed using McNemar-Bowker test. A p value of <0.05 was considered statistically significant.

Results

In all, 95 qualified DM patients were enrolled in this study, including 44 males and 51 females. Numbers of current users of cigarettes and areca were 19 (20.0%) and 6 (6.3%), respectively. Brushing of teeth was carried out once a day at most, and none of the patients had a habit of using mouthwash (Table 1).

Among these patients, 70.5% (67/95) presented with periodontitis (CPI 3-4 points) in the initial epoch. This decreased to only 20.0% (19/95) in the final epoch. Significant changes in periodontal status ($p<0.01$) revealed the long-term effects of good oral health behaviors and habits gleaned from a series of oral health education courses (Table 2).

Major determinants of the long-term variations in periodontal status were changes in utilization habits of cigarettes and dental floss on GEE modeling. Long-term trend of non-periodontitis (CPI 0-2 points) was 2.38-fold (never vs current user) among cigarette users and 3.26-fold (current user vs never) among dental floss users (Table 3).

Discussion

Previous studies on the effectiveness of DM management have focused on improving both the provision of DM care and treatment prognosis[17],

Table 1. Descriptive analysis of baseline demographic data (N=95)

Variables	Number	Percentage	Mean	S.D
Gender				
male	44	46.3		
female	51	53.7		
Cigarette use				
never	59	62.1		
former user	17	17.9		
current user	19	20.0		
Areca use				
never	86	90.5		
former user	3	3.2		
current user	6	6.3		
Brushing of teeth (times per day)				
once or less	95	100.0		
twice	0	0.0		
three times or more	0	0.0		
Dental floss use				
never	69	72.6		
former user	14	14.7		
current user	12	12.6		
Mouthwash use				
never	95	100.0		
former user	0	0.0		
current user	0	0.0		
CPI ranking (point)				
0-2	28	29.5		
3-4	67	70.5		
Age (years)			56.4	11.9
Education (years)			6.5	4.7
Disease duration (years)			9.4	3.9

while the longitudinal effect of oral health educational intervention on the correlation between DM and periodontitis has rarely been studied. In this study, compared with epoch 1 (i.e., the 0 month in the initial period of this study), we found elevated odds ratios (ORs) for non-periodontitis from epoch 2 to epoch 5 on GEE model and significant variations in non-periodontitis status between epoch 1 and epoch 5 on McNemar-Bowker test. These results revealed a similar trend of non-periodontitis in DM patients with good oral health management, such as reduction in or stopping cigarette or areca use and increasing frequency of dental floss, mouthwash, and tooth brush use. This

Table 2. Changes in CPI between initial and final epochs (N=95)

Items	Initial epoch		
	3-4 points (n, %)	0-2 points (n, %)	total (n, %)
Final epoch			
3-4 points (n, %)	13 (13.7%)	6 (6.3%)	19 (20.0%)
0-2 points (n, %)	54 (56.8%)	22 (23.1%)	76 (80.0%)
total (n, %)	67 (70.5%)	28 (29.4%)	95 (100%)

McNemar-Bowker test, $\alpha=0.05$, $\chi 2=38.400$, $p<0.001$.

indicates that changes in oral health management play an important role in the improvement in periodontal status among DM patients. In other words, a good oral health education course can help DM patients to develop good oral health behaviors or habits and reduce prevalence of periodontitis. However, follow up treatment for periodontal problems may serve as a potential confounder in this study.

A longitudinal study on the association between periodontal disease and the development of metabolic syndrome has indicated that the presence of periodontal pockets is associated with positive conversions of metabolic-syndrome components. The authors of that study suggested that prevention of periodontal disease can prevent metabolic syndrome[33]. Reduction in levels of blood glucose after effective periodontal treatment in DM patients has been reported in previous intervention studies on periodontal disease and DM[34,35]. Other studies have assessed the periodontal status in type 1 DM patients and healthy individuals, and found good evidence for increased risk of periodontal disease in type 1 DM. Poor metabolic control of DM together with smoking and inadequate oral hygiene increase the risk of severe periodontal disease in patients with type 1 DM[6,29]. In our study, we found similar long-term effects associated with changes in smoking status and dental floss utilization. Those who 'never' smoked had a 2.38 OR, which was comparable with that of 'current' smokers without periodontitis. There was also no significant difference in ORs (p=0.285, OR 1.70) between former and current smokers. Current users of dental floss demonstrated better periodontal status (CPI 0-2 points) than those who had 'never' used dental floss on GEE model.

Long-term trends in gum health were well-

Table 3. GEE modeling for predictive factors of non-periodontitis condition

Variables	B	SE	p value	OR	95% CI of OR	
					lower	upper
Epochs						
epoch 5	2.080	0.652	0.001	8.00	2.22	28.72
epoch 4	1.732	0.373	<0.001	5.65	2.71	11.75
epoch 3	0.769	0.336	0.022	2.15	1.11	4.17
epoch 2	0.701	0.326	0.032	2.01	1.06	3.82
Male	0.155	0.268	0.564	1.16	0.69	1.97
Age (years)	0.002	0.018	0.926	1.00	0.96	1.03
Education (years)	0.029	0.032	0.370	1.03	0.96	1.09
Disease duration (years)	0.015	0.033	0.664	1.01	0.95	1.08
Cigarette use						
never	0.869	0.373	0.020	2.38	1.14	4.95
former user	0.533	0.499	0.285	1.70	0.64	4.53
Areca use						
never	1.190	0.686	0.083	3.28	0.85	12.62
former user	0.304	0.793	0.702	1.35	0.28	6.42
Dental floss use						
current user	1.182	0.533	0.027	3.26	1.14	9.27
former user	0.837	0.501	0.095	2.31	0.86	6.17
Mouthwash use						
current user	0.372	0.760	0.624	1.45	0.32	6.43
former user	0.047	0.864	0.956	1.04	0.19	5.70
Brushing of teeth (times per day)						
three times or more	0.477	0.693	0.492	1.61	0.41	6.27
twice	0.354	0.673	0.599	1.42	0.38	5.33

Ten predictors in GEE model include epochs (reference=epoch 1), gender, education, disease duration, cigarette and areca use (reference=current user), dental floss and mouthwash use (reference=never), and frequency of tooth brushing (reference=once or less per day). p<0.05 means a significant trend compared to non-periodontitis.

established in our DM patients who developed good oral health behaviors and habits (Table 3). Although some studies have not found or identified a significant association between DM and periodontal inflammation, higher prevalence and severity of periodontitis have been demonstrated in DM patients[36,37]. In the Indian population, periodontal disease and dental caries are the most prevalent dental diseases. Oral health awareness and practices among this study population are poor. Gender, literacy, urban residence, and mouthwash use are all associated with good oral hygiene practices[38]. There is an urgent need to establish a comprehensive educational program to promote good oral health and provide education regarding correct oral hygiene practices[39].

Limitations of this study include small sample size and short duration. We could not confirm real correlations between changes in blood glucose levels and degrees of periodontal improvement.

Conclusion

The association between DM and periodontal diseases is well-established. Oral and periodontal health interventions should be promoted as integral management components of the diabetic process. We focused on and identified the long-term effects of oral health educational courses on improving periodontitis in DM patients in this longitudinal cohort study. In conclusion, we suggest that DM patients with periodontitis be made aware of oral health management practices to avoid bidirectional influences of complications of DM and periodontitis. In addition, further large-scale research including analysis of confounders is required to confirm our findings.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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